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(54) **METHODE ET SYSTEME DE TRANSFERT DE DONNEES NUMERIQUES ENTRE DESTINATIONS DIFFERENTES**
(54) **METHOD AND SYSTEM FOR TRANSFERRING DIGITAL DATA CALLS BETWEEN DIFFERENT DESTINATIONS**
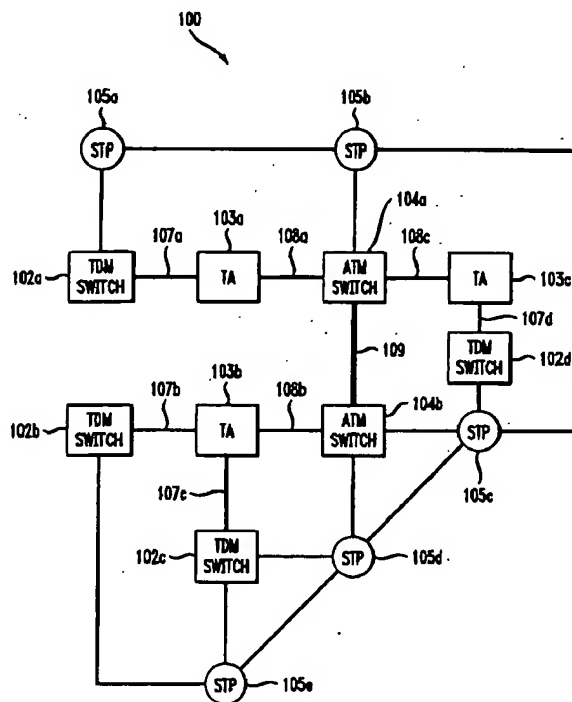
(57) Systems and methods for handling different types of alarm signals, such as red, blue, and/or yellow alarm signals, in hybrid time division multiplexing (TDM)/asynchronous transfer mode (ATM) networks. A terminal adapter, which may be in the form of a stand-alone device and/or integrated with an ATM switch, may receive an alarm signal from a TDM switch. Based on the nature of the alarm signal, the terminal adapter may send a message to the ATM switch and/or acknowledge to the TDM switch that the terminal adapter has received the alarm signal from the TDM switch. The ATM switch, upon receiving the message from the terminal adapter, may route appropriate other messages to other ATM switches and/or TDM switches in the hybrid network. Other ATM switches receiving such messages may in turn route appropriate messages via the signaling network to other ATM switches and/or TDM switches.

SYSTEM AND METHOD FOR HANDLING TDM ALARM SIGNALS
IN THE ATM DOMAIN

Abstract

5   Systems and methods for handling different types of alarm signals, such as red, blue, and/or yellow alarm signals, in hybrid time division multiplexing (TDM) / asynchronous transfer mode (ATM) networks. A terminal adapter, which may be in the form of a stand-alone device and/or integrated with an ATM switch, may receive an alarm signal from a TDM switch. Based on the nature of the alarm signal, the terminal adapter may send a

10   message to the ATM switch and/or acknowledge to the TDM switch that the terminal adapter has received the alarm signal from the TDM switch. The ATM switch, upon receiving the message from the terminal adapter, may route appropriate other messages to other ATM switches and/or TDM switches in the hybrid network. Other ATM switches receiving such messages may in turn route appropriate messages via the signaling network to

15   other ATM switches and/or TDM switches.

SYSTEM AND METHOD FOR HANDLING TDM ALARM SIGNALS
IN THE ATM DOMAIN

5 ### Field of the Invention

The present invention is directed generally to a system and method for handling time division multiplexing (TDM) alarm signals in the asynchronous transfer mode (ATM) domain in a hybrid TDM/ATM network.

10 ### Background

In telecommunications systems, time division multiplexing (TDM) networks are currently often used for carrying voice calls and data transfers. However, the use of asynchronous transfer mode (ATM) networks is becoming more desirable in telecommunications systems because ATM technology is superior in many ways to TDM

15 technology. Although it is doubtful that ATM technology will completely replace TDM technology in the near future, it is likely that ATM technology will be incrementally integrated into current TDM telecommunications systems.

In order for ATM to penetrate the bulk of the telecommunications systems, there is a need to be able to interface TDM networks seamlessly with ATM networks. In particular,

20 there is a need to communicate failures in the TDM domain into and through the ATM domain, and vice versa. In the TDM network architecture, there are embedded mechanisms for communicating and handling network failures. However, in conventional hybrid TDM/ATM networks, if a failure occurs in the TDM domain, the ATM domain would not be notified of the TDM failure. Further, when first and second TDM units are connected

25 together via a conventional ATM network in a manner that is conventionally known, the second TDM unit would not be notified of a failure in the first TDM unit.

Summary of the Invention

At least the above-described problems are solved by implementing various aspects of the present invention. To achieve seamless operation of time division multiplexing (TDM) / asynchronous transfer mode (ATM) hybrid networks, the present invention defines a

5 network architecture for converting between TDM alarm signals and messages compatible with the ATM domain. To accomplish this, the present invention exploits both TDM network alarming protocols as well as standard narrowband and broadband signaling to achieve seamless operation of TDM/ATM hybrid networks.

Specifically, according to one aspect of the present invention, methods and apparatus

10 are described for generating an alarm message in an ATM network responsive to receiving a TDM alarm signal. The alarm message may be a standard narrowband and/or broadband signal in the ATM domain and may be routed through the ATM network utilizing standard user-to-network signaling and/or network signaling. An example of apparatus for performing this aspect of the present invention is apparatus that may include a TDM

15 interface configured to be connected to the TDM network and further configured to generate a first signal responsive to receiving a TDM alarm signal from the TDM network, a processor connected to the TDM interface and configured to generate a second signal responsive to receiving the first signal, and/or an ATM interface connected to the processor and configured to generate an ATM alarm message responsive to receiving the second

20 signal.

According to another aspect of the present invention, methods and apparatus are described for efficiently routing the message through an ATM portion of the network and/or for sending trunk blocking and/or unblocking alarm messages to the TDM domain, such as to a destination TDM switch. In response to the blocking and/or unblocking alarm

25 messages, the destination TDM switch may mark an alarmed trunk associated with the TDM alarm signal as being out of service.

According to yet another aspect of the present invention, methods and apparatus are described for generating TDM alarm signals responsive to an ATM alarm message and/or a disruption occurring in an ATM network. An example of apparatus for performing this

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aspect of the present invention is apparatus that may include an ATM interface connected to the processor and configured to generate a first signal responsive to detecting a disruption in the ATM network, a processor connected to the ATM interface and configured to generate a second signal responsive to receiving the first signal, and/or a TDM interface connected to

5   the processor and configured to generate a TDM alarm signal responsive to receiving the second signal.

Brief Description of the Drawings

The foregoing summary of the invention, as well as the following detailed

10   description of preferred embodiments, is better understood when read in conjunction with the accompanying drawings, which are included by way of example, and not by way of limitation with regard to the claimed invention.

Fig. 1 illustrates an embodiment of a hybrid TDM/ATM network that may be implemented according to aspects of the present invention.

15   Fig. 2 is a flow diagram illustrating steps that may be taken by the hybrid TDM/ATM network of Fig. 1 responsive to a TDM alarm signal.

Fig. 3 illustrates an embodiment of a terminal adapter consistent with the TDM/ATM network illustrated in Fig. 1.

Detailed Description of Preferred Embodiments

20

Referring to Fig. 1, a hybrid time division multiplexing (TDM) / asynchronous transfer mode (ATM) network 100 may comprise a plurality of TDM switches 102a, 102b, 102c, 102d (hereby referred to collectively as reference number 102) and a plurality of ATM switches 104a, 104b (hereby referred to collectively as reference number 104).

25   Some or all of the ATM switches 104 may be connected with one or more of the TDM switches 102 through one or more terminal adapters 103a, 103b, 103c (hereby referred to collectively as reference number 103). The ATM switches 104 may be connected to the terminal adapters 103 via user-network interface (UNI) links 108a, 108b, 108c (hereby referred to collectively as reference number 108). Some or all of the ATM switches 104

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may further be connected to a separate and/or integrated signaling network, which may include interconnected signaling processors, also commonly known as signal transfer points (STPs) 105a, 105b, 105c, 105d, 105e (hereby referred to collectively as reference number 105). One or more of the terminal adapters 103 may be connected to one or more of the TDM switches 102 via one or more TDM trunk subgroups / trunks 107a, 107b, 107c, 107d (hereby referred to collectively as reference number 107).

The TDM switches 102 may be part of central offices in a telephone network. The TDM switches 102 may be any type of TDM switches or other standard TDM devices. For example, the TDM switches 102 may include AT&T 4ESS switches and/or AT&T 5ESS switches.

The terminal adapters 103 may be distinct units and/or they may be part of the TDM switches 102 and/or the ATM switches 104 (e.g., terminal adapter 103a may be a line card in ATM switch 104a). Examples of embodiments of a terminal adapter are described in U.S. Patent No. 5,483,527, "Terminal Adapter for Interfacing an ATM Network with a STM Network," issued on January 9, 1996 to Doshi et al., which is hereby incorporated by reference as to its entire contents. Another example of an embodiment of a terminal adapter 103 in accordance with aspects of the present invention is the AXC 2000™ ATM Switch Core, which is currently marketed by Lucent Technologies.

There exists in the TDM domain at least one alarm protocol for defining and activating alarm status conditions and for generating alarm signals in response to system failures. For instance, the AT&T *ACCUNET*® T1.5 Service (a TDM service) utilizes a TDM alarm protocol as described in AT&T Technical Reference Publication No. TR 62411. Under this particular TDM alarm protocol, both "alarm signals" and "alarm states" are defined. Although the above-identified AT&T TDM alarm protocol is utilized herein as an illustrative embodiment, the present invention may be implemented using any TDM alarm protocol.

The term "alarm signal" in both this specification and the accompanying claims refers to a signal transmitted upstream and/or downstream warning that a system failure

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has been detected, and/or a lack of a sufficient signal caused by a system failure. For example, alarm signals in the above-identified AT&T TDM alarm protocol include a Blue alarm signal (also commonly referred to as an Alarm Indication Signal or a "Keep-Alive" signal), a Yellow alarm signal (also commonly referred to as a Remote Alarm Indication

5   Signal), and a Loss of Signal (LOS). The Blue alarm signal is an unframed "all-ones" signal that is transmitted in lieu of a normal signal upon loss of an originating signal, or when any action is taken that would cause a signal disruption. The Yellow alarm signal indicates a carrier failure in the transmit direction. A LOS is not actually a signal in and of itself, and it is not actually defined as an alarm signal in the above-identified alarm

10   protocol. In reality, a LOS is actually an incoming signal that has insufficient framing and/or pulses, or a lack of any incoming signal whatsoever. However, for the sake of convenience, the LOS will be considered herein as an alarm signal.

The term "alarm state" in both this specification and the accompanying claims refers to a condition activated at a terminal alerting that maintenance action is required.

15   For example, the alarm states in the above-identified AT&T TDM alarm protocol include an Alarm Indication Signal (AIS) Carrier Failure Alarm (CFA) state, a Red CFA state, a Yellow CFA state, and a LOS alarm state. The AIS CFA alarm state is activated in a first unit responsive to the first unit detecting a Blue alarm signal from a second unit upstream from the first unit. The Red CFA alarm state is activated in a first unit responsive to first

20   unit detecting, on an incoming line, a system failure. The Yellow CFA alarm state is activated in a unit responsive to the first unit detecting a Yellow alarm signal received from a second unit that is in a Red CFA alarm state. The LOS alarm state is activated in a first unit responsive to the first unit receiving an insufficient incoming signal or no incoming signal whatsoever.

25   Further, according to the above-identified TDM alarm protocol, a first unit will transmit a Yellow alarm signal upstream responsive to any alarm state being activated in the first unit. In this way, notification of a system failure in a TDM network is propagated throughout the TDM domain portion of a TDM/ATM hybrid network that is affected by the system failure.

In order to notify the ATM portion of the TDM/ATM hybrid network of the system failure, the TDM domain alarm signals must be transferred and/or translated into messages compatible with the ATM domain (and vice-versa). However, to accomplish translation between the TDM domain and the ATM domain, it is desirable that there be

5 some relationship, or mapping, between the TDM trunk subgroups / trunks 107 in the network 100 and the ATM virtual path identifiers (VPIs) / virtual channel identifiers (VCIs) in the network 100. Previous work has shown that a mapping can be defined between VPIs and trunk subgroups and/or between VCIs and trunks, for example as described in U.S. Patent No. 5,483,527. Such mapping may be, for example, a one-to-

10 one, into and onto mapping between trunk subgroups and VPIs and/or between trunks and VCIs.

As will be described below, in some embodiments of the present invention, mapping allows a terminal adapter 103 to (1) identify which problem trunk / trunk subgroup 107 (or plurality of problem trunks / trunk subgroups 107) is transmitting a

15 TDM domain alarm signal to the terminal adapter 103; (2) translate the TDM domain alarm signal into an ATM alarm message; and/or (3) label the ATM alarm message with VPI/VCI information corresponding to the problem trunk / trunk subgroup 107. Accordingly, the identity of the problem trunk / trunk subgroup 107 can be maintained across the TDM domain / ATM domain border. Similarly, in further embodiments of the

20 present invention, mapping allows a terminal adapter 103 to (1) receive an ATM alarm message labeled with VPI/VCI information; (2) translate the ATM alarm message into a TDM domain alarm signal; and/or (3) send the TDM domain alarm signal to the destination TDM switch 102 on the destination trunk / trunk subgroup 107.

In the ATM domain, a signaling protocol is defined for the link between a UNI

25 device and an ATM switch. This type of signaling is commonly known as user-to-network signaling. Standards for user-to-network signaling in the ATM domain are currently defined by International Telecommunication Union - Telecommunications (ITU-T) Q.2931 (ATM Forum UNI specification, Bellcore TA-NWT-001111). Under these standards, a default signaling virtual path / virtual channel (SiVC) is used for user-to-

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network signaling in an ATM network. According to the Q.2931 standard, the default SiVC is VPI/VCI = 0/5.

A signaling protocol in the ATM domain is also defined for the links between ATM switches. This type of signaling is commonly known as network signaling. ATM

5   network signaling standards are currently defined by ITU-T Signaling System No. 7 (SS7) (Bellcore specification TR-NPL-000246), which is the current generation of the common-channel signaling standard. In the North America, network signaling is generally accomplished via a separate signaling network (e.g., the signaling network in Fig. 1). However, in other parts of the world, network signaling is sometimes implemented

10   directly between ATM switches. SS7 defines various signaling protocols such as the broadband integrated services digital network user part (B-ISUP) signaling protocol. The B-ISUP protocol provides basic and supplementary signaling functions for support of various voice and nonvoice applications. The B-ISUP signaling protocol also defines various narrowband and broadband signaling messages. For instance, B-ISUP defines

15   such narrowband messages as "BLOCKED TRUNK" and "UNBLOCKED TRUNK," and such broadband messages as "BLOCKED STREAM" and "UNBLOCKED STREAM."

In some embodiments of the present invention, UNI devices may be embodied as terminal adapters 103. Thus, user-to-network signaling on an SiVC may be utilized

20   between the terminal adapters 103 and the ATM switches 104. Accordingly, in these embodiments one or more default SiVCs may be used to transfer signaling between the terminal adapters 103 and the ATM switches 104.

In some embodiments of the present invention, some or all of the above-identified SS7 messages and/or user-to-network messages may be effectively implemented as ATM

25   alarm messages. For example, between ATM switches 104, the "BLOCKED STREAM" and/or "UNBLOCKED STREAM" broadband messages may be utilized as a ATM alarm message. Between an ATM switch 104 and a TDM switch 102, the "BLOCKED TRUNK" and/or "UNBLOCKED TRUNK" narrowband messages may be used as an ATM alarm message. Between a terminal adapter 102 and an ATM switch 104, a user-to-

network message may be used as an ATM alarm message. Descriptions of how the network 100 may utilize various ATM alarm messages are presented further below.

In further embodiments of the present invention, one or more of the terminal adapters 103 may be configured to receive and/or interpret some or all of the TDM

5   domain alarm signals (e.g., a Blue alarm signal, a Yellow alarm signal, and/or a LOS). One or more of the terminal adapters 103 may be further configured to transmit one or more appropriate ATM alarm messages responsive to receiving and/or not receiving a TDM domain alarm signal. For example, responsive to receiving a Yellow alarm signal or a LOS from a TDM switch 102 in the TDM domain, a terminal adapter 103 may

10   transmit a particular alarm signal to an ATM switch 104 in the ATM domain.

In operation, if terminal adapter 103a, for example, receives a LOS from TDM switch 102a over trunk / trunk subgroup 107a, then terminal adapter 103a may identify the fact that there is inadequate signal framing and/or pulses in the incoming signal. In response to the LOS, terminal adapter 103a may send a Yellow alarm signal back to TDM

15   switch 102a (if terminal adapter 103a is configured to operate using the above-identified TDM alarm protocol). Further, terminal adapter 103a may signal ATM switch 104a over UNI link 108a using appropriate user-to-network signaling that each of the VPIs/VCIs associated with the alarmed trunk / trunk subgroup 107a are to be blocked. Terminal adapter 103a may further enter an appropriate alarm state to allow the craft to sectionalize

20   the trouble.

In another example, if terminal adapter 103a receives a Blue alarm signal from TDM switch 102a, then terminal adapter 103a may signal ATM switch 104a via appropriate user-to-network signaling that each of the VIPs/VCIs associated with the alarmed trunk / trunk subgroup 107a are to be blocked. Terminal adapter 103a may

25   further enter an appropriate alarm state to allow the craft to sectionalize the trouble.

In a further example, if terminal adapter 103a receives a Yellow signal from TDM switch 102a, then terminal adapter 103a may signal ATM switch 104a via appropriate user-to-network signaling that each of the VIPs/VCIs associated with the alarmed trunk /

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trunk subgroup 107a are to be blocked. Terminal adapter 103a may further enter an appropriate alarm state to allow the craft to sectionalize the trouble.

Further, one or more of the terminal adapters 103 may be configured to receive and/or interpret some or all of various ATM alarm messages. One or more of the
5   terminal adapters 103 may be still further configured to transmit one or more appropriate TDM domain alarm signals responsive to receiving and/or not receiving an ATM alarm message, and/or responsive to a disruption occurring in the ATM domain. For example, responsive to receiving a particular ATM alarm message or a LOS in the ATM domain, a terminal adapter 103 may transmit a particular alarm signal in the TDM domain (e.g., a
10   Yellow alarm signal). Thus, for example, if there is a problem with UNI link 108a in the ATM domain connecting terminal adapter 103a with ATM switch 104a, then the terminal adapter 103a may generate and transmit a Blue alarm signal to the TDM switch 102a if the TDM switch 102a is downstream from the terminal adapter 103a. If the TDM switch 102a is upstream from the terminal adapter 103a, the terminal adapter 103a may generate
15   and transmit a Yellow alarm signal to the TDM switch 102a.

In further embodiments of the present invention, one or more of the terminal adapters 103 may be configured to recognize which TDM alarm protocol is being used in the TDM domain portion of the network 100. Accordingly, the terminal adapters 103 may be capable of operating using one or more of a plurality of TDM alarm protocols
20   and/or automatically select one or more TDM alarm protocols to be used depending upon the TDM alarm protocol(s) being used in the TDM domain portion of the network 100. Further, the terminal adapters 103 may be selectively configured by a network user to operate using one or more of a plurality of TDM alarm protocols.

In each of the examples described above, ATM switch 104a and/or a remainder of
25   the ATM portion of the network 100 may respond differently to the user-to-network signaling sent from terminal adapter 103a, depending upon the configuration of the problem trunk / trunk subgroup 107 and/or UNI link 108 within the network 100. To illustrate how the network 100 may respond in various situations, two scenarios are presented below with reference to Fig. 2.

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In the first scenario, it is assumed that a connection is established (or attempted to be established) between TDM switch 102a and TDM switch 102b. Thus, a connection may be established between TDM switch 102a and TDM switch 102b via terminal adapter 103a, ATM switch 104a, ATM switch 104b, and terminal adapter 103b. In such a

5   scenario, terminal adapter 103a may receive a TDM alarm signal from TDM switch 102a (step S201). In response, terminal adapter 103a may signal ATM switch 104a via broadband user-to-network signaling that each of the VPIs/VCIs associated with the alarmed trunk (trunk 107a) are to be blocked (step S202). When ATM switch 104a receives the user-to-network signaling from terminal adapter 103a, the routing table of

10   ATM switch 104a would indicate that the VPI/VCI associated with the next point in the connection route is ATM switch 104a (step S203). Accordingly, ATM switch 104a may send a broadband "BLOCKED STREAM" message to ATM switch 104b (step S206). ATM switch 104a may send the "BLOCKED STREAM" message to ATM switch 104b via the signaling network (e.g., via STP 105b and 105c) and/or directly to ATM switch

15   104b. Upon ATM switch 104b receiving the "BLOCKED STREAM" message, the routing table of ATM switch 104b would indicate that the VPI/VCI associated with the next point in the connection route is TDM switch 102b (step S203). Accordingly, ATM switch 104b may send a "BLOCKED TRUNK" message to TDM switch 102b via the SS7 network (step S204). Upon receiving the "BLOCKED TRUNK" message, TDM switch

20   102b may mark trunk 107a as being out of service (step S205).

In the second scenario, it is assumed that a connection is established (or attempted to be established) between TDM switch 102a and TDM switch 102d. Thus, a connection may be established between TDM switch 102a and TDM switch 102d via terminal adapter 103a, ATM switch 104a, and terminal adapter 103b. In such a scenario, when ATM

25   switch 104a receives the user-to-network signaling from terminal adapter 103a, the routing table of ATM switch 104a would indicate that the VPI/VCI associated with the next point in the connection route is TDM switch 102d (step S203). Accordingly, ATM switch 104a may send a "BLOCKED TRUNK" message to TDM switch 102d via the SS7

network (step S204). Upon receiving the "BLOCKED TRUNK" message, TDM switch 102d may mark trunk 107a as being out of service (step S205).

When an alarm clears (i.e., stops), some or all of the network components may perform a similar routine as described above for the two above-described scenarios,

5   except that the message type may be different. For example, responsive to an alarm clearing, similar procedures may be followed by the network 100 with the exception that a "BLOCKED TRUNK" message may be replaced with an "UNBLOCKED TRUNK" message, and/or a "BLOCKED STREAM" message may be replaced with an "UNBLOCKED STREAM" message.

10   Referring to Fig. 3, a terminal adapter 300 may be part of an ATM switch or a separate unit. The terminal adapter 300 here may be implemented as one or more of the terminal adapters 103 in the network 100 illustrated in Fig. 1, and may be a separate unit or incorporated into an ATM switch. An example of an ATM switch that incorporates apparatus functioning as a terminal adapter is the M20 ATM switch, marketed by NEC.

15   The terminal adapter 300 may include one or more TDM interfaces 301a, 301b, 301c (hereby referred to collectively as reference number 301). One or more of the TDM interfaces 301 may be embodied as, for instance, DS1 interface cards, and one or more of the TDM interfaces 301 may include ports (not shown) for connecting to one or more TDM switches via one or more TDM trunks 302a, 302b, 303c (hereby referred to collectively as reference number 302). The TDM trunks 302 may be the TDM trunks 107

20   collectively as reference number 302). The TDM trunks 302 may be the TDM trunks 107 illustrated in Fig. 1. The TDM interfaces 301 may be connected to other parts of the terminal adapter directly and/or via a bus 306. A processor 303 may be connected to the TDM interfaces 301 for receiving, sending, and/or processing TDM data sent to and/or from the TDM trunks 302. The processor 303 may be a network management processor.

25   The processor 303 may further be connected to a storage device such as memory 307 and/or at least one ATM interface 304. If the terminal adapter 300 is a part of an ATM switch, then the processor 303 may either be a separate processor from the processor(s) controlling the remainder of the ATM switch or the processor 303 may be a part of the processor(s) controlling the remainder of ATM switch. If the terminal adapter 300 is a

separate unit (i.e., not a physical part of an ATM switch), then the ATM interface 304 may be connected to an ATM switch via at least one link 305 such as a UNI link. If the terminal adapter 300 is a part of an ATM switch, then the link 305 may be of a configuration that is compatible with the manner in which the terminal adapter 300 is
5 incorporated into the ATM switch.

When a TDM trunk (e.g., TDM trunk 302a) has an alarm signal on it (e.g., a yellow alarm signal), the TDM interface 301a may receive the alarm signal via the port through which the alarmed TDM trunk 302a is connected. If the TDM interface 301a is a DS1 interface card, port firmware on the DS1 interface card may turn on an alarm
10 indicator on the DS1 interface card for the particular port that receives the alarm signal. Further, the TDM interface 301a may send a first signal to the processor 303, notifying it that the port and/or the TDM trunk 302a is in an alarmed state. Responsive to the first signal, the processor 303 may log the alarm into the memory 307 and/or other storage, and/or the processor 303 may send an SNMP/CMIPS/OTHER message to a central
15 network manager. Responsive to the first signal, the processor 303 may also send a second signal to the ATM interface 305. The processor 303 and/or the ATM interface may generate one or more ATM alarm messages in order to notify downstream units that the TDM trunk 302a is out of service. Thus, the second signal generated by the processor 303 may be an ATM alarm message. The processor 303 and/or the ATM interface 305
20 may generate an ATM alarm message by building ATM cells in the manner described in U.S. Patent No. 5,483,527. As described above, the ATM cells may be assigned to one or more SiVCs or other predetermined VPIs/VCIs set aside for signaling purposes. If the terminal adapter 300 is separate from an ATM switch, then responsive to the alarm signal, the ATM interface 304 may signal an ATM switch via user-to-network signaling. If the
25 terminal adapter 300 is incorporated into an ATM switch, then responsive to the alarm signal, the combination terminal adapter / ATM switch may send broadband and/or narrowband signaling messages to a signaling network, such as to an STP 105 as shown in Fig. 1.

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The ATM interface 305 may be configured to detect a disruption in the ATM network, such as in the ATM link to which the ATM interface 305 is connected. When the ATM interface 305 detects such a disruption, the ATM interface 305 may send a first signal to the processor 303. Responsive to the first signal, the processor 303 may send a

5   second signal to one or more of the TDM interfaces 301, notifying them of the disruption in the ATM domain. Responsive to the second signal, one or more of the TDM interfaces 301 may send a TDM alarm signal (e.g., a Yellow alarm signal and/or a Blue alarm signal) to one or more TDM trunks 302.

Any United States patents referred to herein should be deemed to be incorporated by

10   reference as to their entire contents.

While exemplary systems and methods embodying the present invention are shown by way of example, it will be understood, of course, that the invention is not limited to these embodiments. Modifications may be made by those skilled in the art, particularly in light of the foregoing teachings. For example, each of the elements of the aforementioned

15   embodiments may be utilized alone or in combination with elements of the other embodiments.

Claims:

1.   A method comprising the step of generating a first alarm message in an asynchronous transfer mode (ATM) network responsive to receiving a time division multiplexing (TDM) alarm signal.

5   2.   The method of claim 1 wherein the TDM alarm signal is a Blue alarm signal.

3.   The method of claim 1 wherein the TDM alarm signal is a Yellow alarm signal.

4.   The method of claim 1 wherein the TDM alarm signal is a loss of signal.

5.   The method of claim 1 wherein the first alarm message is an ATM user-to-
10   network signaling message.

6.   The method of claim 1 further including the step of routing a second alarm message associated with the first alarm message through the ATM network.

7.   The method of claim 6 wherein the second alarm message is a "BLOCKED STREAM" message.

15   8.   The method of claim 6 wherein the second alarm message is a "BLOCKED TRUNK" message.

9.   The method of claim 6 wherein the second alarm message is the first alarm message.

10.   The method of claim 1 wherein the TDM alarm signal is generated by a first
20   TDM switch associated with an alarmed trunk, the method further including the step of sending a second alarm message associated with the first alarm message to a second TDM

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switch, wherein the second TDM switch marks the alarmed trunk as out of service responsive to receiving the second alarm message.

11.   In an asynchronous transfer mode (ATM) network, a method comprising the step of generating a time division multiplexing (TDM) alarm signal responsive to a
5   disruption occurring in the ATM network.

12.   The method of claim 10 wherein the TDM alarm signal is a Blue alarm signal.

13.   The method of claim 10 wherein the TDM alarm signal is a Yellow alarm signal.

10   14.   An apparatus configured to be connected to a TDM network, the apparatus comprising:
       a time division multiplexing (TDM) interface configured to be connected to the TDM network and further configured to generate a first signal responsive to receiving a TDM alarm signal from the TDM network;
15   a processor connected to the TDM interface and configured to generate a second signal responsive to receiving the first signal; and
       an asynchronous transfer mode (ATM) interface connected to the processor and configured to generate an ATM alarm message responsive to receiving the second signal.
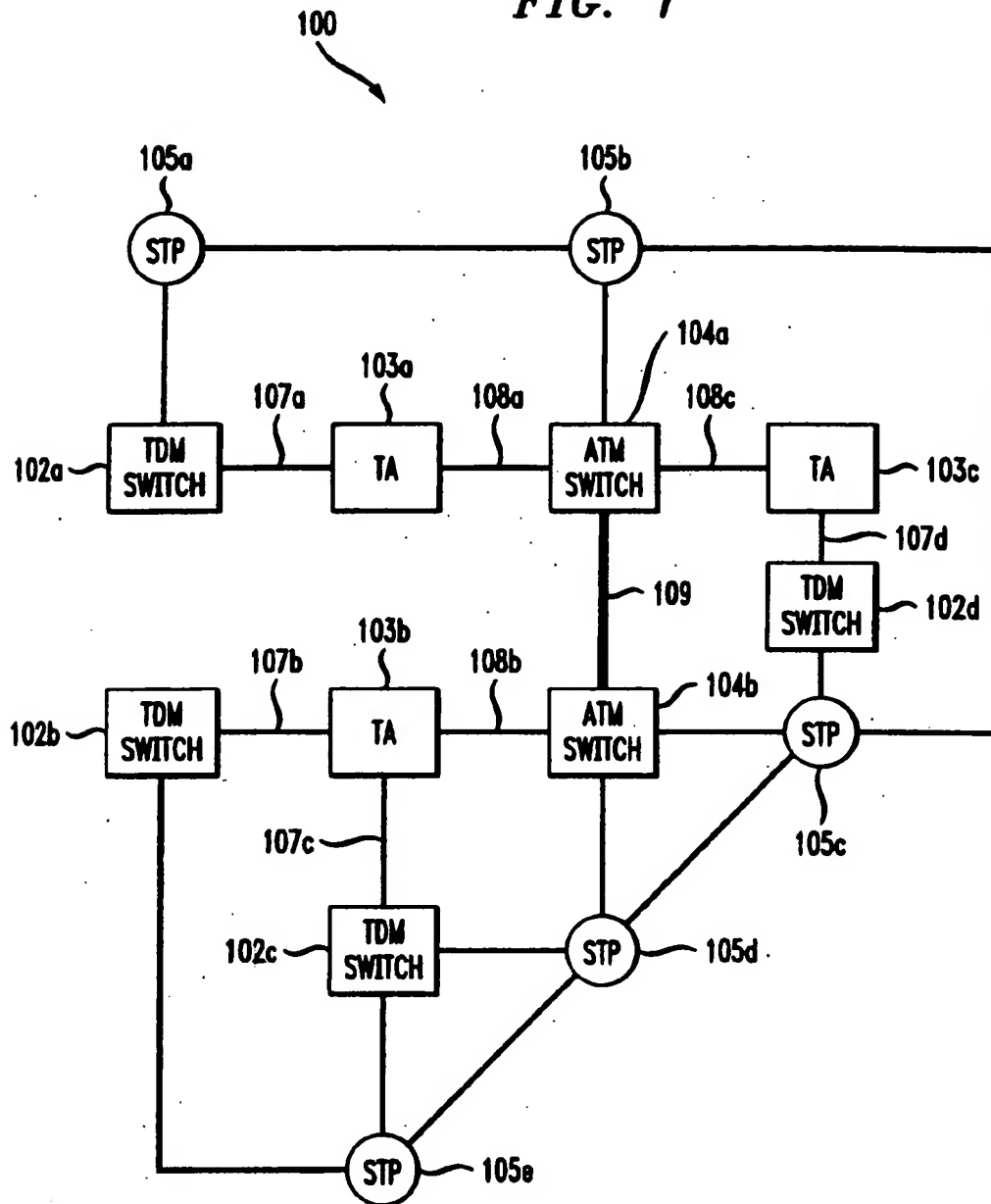
15.   The apparatus of claim 14 wherein the TDM alarm signal is a Blue alarm
20   signal.

16.   The apparatus of claim 14 wherein the TDM alarm signal is a Yellow alarm signal.

17. The apparatus of claim 14 wherein the TDM alarm signal is a loss of signal.

18. The apparatus of claim 14 wherein the ATM alarm message is an ATM user-to-network signaling message.

19. The apparatus of claim 14 wherein the apparatus is configured to be
5   incorporated into an ATM switch.

20. The apparatus of claim 14 further including a memory connected to the processor, wherein the processor is further configured to log the TDM alarm signal in the memory.

21. An apparatus configured to be connected to an ATM network, the apparatus
10   comprising:

an asynchronous transfer mode (ATM) interface connected to the processor and configured to generate a first signal responsive to detecting a disruption in the ATM network;

a processor connected to the ATM interface and configured to generate a second
15   signal responsive to receiving the first signal; and

a time division multiplexing (TDM) interface connected to the processor and configured to generate a TDM alarm signal responsive to receiving the second signal.

22. The method of claim 10 wherein the TDM alarm signal is a Blue alarm signal.

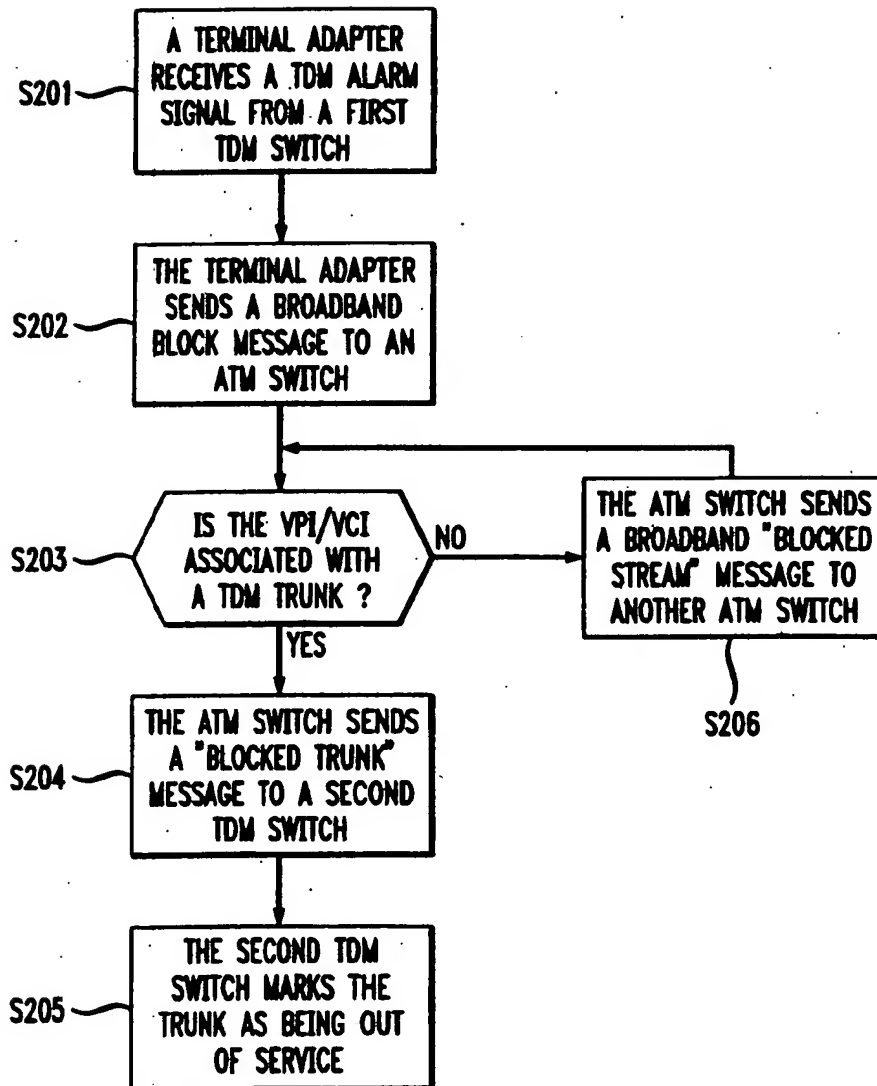20   23. The method of claim 10 wherein the TDM alarm signal is a Yellow alarm signal.

FIG. 1

FIG. 2

S201 — A TERMINAL ADAPTER RECEIVES A TDM ALARM SIGNAL FROM A FIRST TDM SWITCH

S202 — THE TERMINAL ADAPTER SENDS A BROADBAND BLOCK MESSAGE TO AN ATM SWITCH

S203 — IS THE VPI/VCI ASSOCIATED WITH A TDM TRUNK ?

NO → THE ATM SWITCH SENDS A BROADBAND "BLOCKED STREAM" MESSAGE TO ANOTHER ATM SWITCH — S206

YES

S204 — THE ATM SWITCH SENDS A "BLOCKED TRUNK" MESSAGE TO A SECOND TDM SWITCH

S205 — THE SECOND TDM SWITCH MARKS THE TRUNK AS BEING OUT OF SERVICE

FIG. 3

300

TERMINAL ADAPTER

301a

302a

TDM
INTERFACE

303

PROCESSOR

302b

TDM
INTERFACE

MEMORY 307

301b

305

302c

TDM
INTERFACE

ATM
INTERFACE

304

306

301c